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# US ARMY MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

REPORT NO. 524

## A FIELD EVALUATION OF THE ACOUSTIC REFLEX EAR DEFENDER SYSTEM

Capt J. L. Fletcher, MSC

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Report Submitted 29 November 1961

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A FIELD EVALUATION OF THE ACOUSTIC REFLEX  
EAR DEFENDER SYSTEM

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Psychology Division  
US ARMY MEDICAL RESEARCH LABORATORY  
Fort Knox, Kentucky

21 December 1961

Audition and Auditory Perception in Relation to Performance  
Task 02  
Psychophysiological Studies  
USAMRL Project No. 6X95-25-001

Report No. 524  
USAMRL Project No. 6X95-25-001-02

ABSTRACT

A FIELD EVALUATION OF THE ACOUSTIC REFLEX  
EAR DEFENDER SYSTEM

OBJECT

To determine the effectiveness of the Acoustic Reflex Ear Defender System as a hearing protective device in armored vehicles, and to see whether the time delay in firing induced by this system adversely affects moving target gunnery.

RESULTS

The Acoustic Reflex Ear Defender System was shown to provide 14 db "protection" (reduction in temporary threshold shift) to tank crew members. Its use did not affect moving target gunnery.

RECOMMENDATIONS

It is recommended that the Acoustic Reflex Ear Defender System be adopted for use in armored vehicles.

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# A FIELD EVALUATION OF THE ACOUSTIC REFLEX EAR DEFENDER SYSTEM

## I. INTRODUCTION

Research has shown that the contraction of the tensor tympani and stapedius muscles in response to loud sound (acoustic reflex or AR) can serve to protect against intense impulsive noises (1, 2, 3).

An ear protective device, based upon the AR principle, was developed in service and patented. This system was designed to be incorporated into the armored vehicle intercom system. By interposing a time delay between the closing of the firing switch for the weapon and the actual firing of the weapon, it permits the AR to be elicited by a suitable non-noxious sound generated within the device and transmitted to the vehicle crew members through the intercom system. This procedure is necessary because the rise time of the gunfire impulse is much less than the neural latency of the AR response. It is because of this neural latency that the ear is not normally protected from gunfire by the reflex.

Laboratory results (1, 2, 3) indicate reasonably good protection from gunfire sounds by AR action. Preliminary results from the operational firing of the secondary armament of the M-41 tank, a .30 cal machine gun, support the laboratory findings. However, operationally, combat vehicle crew members wear the CVC helmet and fire the main armament as well as the machine guns at both fixed and moving targets. The .15 sec delay and the activating tone should not affect stationary target marksmanship. To determine the effects of the delay and distraction due to operation of the Acoustic Reflex Ear Defender System, a field evaluation was made.

## II. METHOD

The evaluation of the AR system was divided into two phases. Phase I was designed to demonstrate the ear protective characteristics of the system while the object of Phase II was to determine whether the time delay and the tone interposed by the device adversely affected tank gunnery. Gunnery was not a concern in Phase I and hearing was not considered in Phase II.

Sixteen subjects were initially exposed in Phase I. These subjects were given sufficient preliminary training in the use of the

Békésy audiometer to assure reliable thresholds. They were not screened for hearing deficit.

Temporary threshold shift (TTS) reduction at 4000 cps was used as the criterion of protection. This was evaluated in the following manner. Immediately prior to exposure to firing the subject's threshold for a 4000 cps tone was determined. He was then exposed without reflex activation in an M-41 tank to the firing of the main armament, a 76 mm gun. Promptly upon termination of the firing the subject's threshold for the 4000 cps tone was again determined. The TTS resulting from unprotected (i. e., no deliberate acoustic reflex protection) exposure was compared to that resulting from a similar exposure with the AR system active. The reduction in TTS for the 4000 cps tone accompanying use of the AR system is called "protection," and is presumably due to the attenuation of ambient sound by acoustic reflex action.

The single frequency threshold at 4000 cps was decided upon because exposure to gunfire is most likely to cause a shift at this frequency. Also, TTS recovery is quite rapid and would be taking place while a complete sweep frequency audiogram was being taken.

In Table 1 are presented the relevant data for each subject completed in Phase I regarding noise exposure and level of the sound output of the AR protective system. The level of the sound output of the AR protective device was determined by the individual AN/65 intercom in the tank used. The maximum output level was presented from each and ranged from 94-122 db SPL (as measured by coupling the helmet phones over a General Radio 1551-B Sound Level Meter using the fast setting). Three tanks were used in this phase.

Ideally, order (AR or no AR first or second) should have been counterbalanced. However, it would have been extremely injudicious to expose everyone to the same number of rounds, since some are sensitive and others quite insensitive; so exposure was "tailored" to the individual. Therefore, everyone in Phase I was exposed without the AR system first in order that it could be determined whether sufficient stimulation had been given.

Precise control could not be exerted over the length of time occupied by the firing so it was noted in each case and is presented in Table 1. Notice that subjects, 2, 3, 4, and 5 were exposed to 90 rounds without the AR, only 84 with it. Notice also that the firing

TABLE I

## DATA OF PHASE I

Subject	Without AR			With AR			
	Number of Rounds	Firing Time	Induced TTS (in db)	Number of Rounds	Firing Time	Induced TTS (in db)	AR Sound Output Level (in db)
1	45	7 min	21	45	6 min	10	94
2	90	13 min	7	84	8 min	4	102
3	90	15 min	71	84	8 min	8	102
4	90	13 min	9	84	8 min	-6*	102
5	90	13 min	13	84	8 min	8	102
6	90	16 min	14	90	13 min	-8	122
7	90	16 min	19	90	13 min	16	122
8	90	16 min	15	90	13 min	6	122
9	90	15 min	19	90	13 min	18	122
			$\Sigma 188$				$\Sigma 56$
			$\bar{X} 20.89$				$\bar{X} 6.22$

\*The minus sign indicates the subject heard better after exposure to the firing than before (a negative TTS).



time without the AR was 13-15 min, only 8 min with the AR. Trading speed or rate of firing (duration of exposure) for number of rounds fired, the with AR exposure is at least as noxious as the without because it took at least 5 min less, even though 6 rounds fewer were fired. In other words a smaller number of rounds, fired faster, constitutes as noxious an exposure for hearing as a slightly larger number of rounds fired more slowly permitting more time for TTS recovery between rounds.

Phase II involved the gunnery efforts of 10 expert gunnery instructors from the US Army Armor School Weapons Department. These expert gunners each fired five familiarization rounds, then 10 rounds for record at a 6' x 6' target, moved at about seven miles per hour. The targets were either at 600 or 850 yards range from the gunners. The gunners fired one course of firing (5 rounds familiarization, 10 for record) with the AR system operating in the tank, the other course (also 5 familiarization, 10 for record) without the system functioning. One day separated the two firing courses. Gunnery was scored by use of a spotting scope. The target was divided into three areas, hits in the center area were given six points, those in the next area four points, while all other hits were weighted at two points. No credit was given for misses.

Half the gunners fired first with the system operating, then finished without it. The balance of the gunners reversed this procedure. Each gunner fired all rounds from the same tank. The tanks were never moved during the experiment. Two different tanks were used in Phase II. The maximum output level was presented in each and ranged from 104 db SPL in one tank to 122 db SPL in the other.

In order to maximize motivation, individual over-all scores were kept and monetary prizes awarded to those who scored first, second, or third. Additionally, the gunners used represented two different sections of the Weapons Department so they were divided into A and B groups according to sections and competed as such.

In both Phase I and Phase II the CVC helmet was worn by all subjects under all conditions.

### III. RESULTS

Complete records were obtained from nine of the 16 subjects initially exposed in Phase I. Six subjects were lost due to inability to

induce TTS without AR protection within the limits of the number of rounds fired. Clearly, no purpose could be served by taking more data on these subjects because if no TTS could be induced in the unprotected state, no "protection" (reduction in TTS with AR activation) could be shown. The cost of further firing as well as the scheduling of the ranges prevented further attempts to induce TTS in these six subjects. A records error invalidated the results of the seventh subject.

The results from Phase I (Table 1) show that the mean TTS for the nine subjects with no AR protection was 20.89 db, with AR protection the TTS was 6.22 db, a 14.67 db difference in favor of the AR. This difference is of statistical and practical significance and closely approximates past laboratory findings (1, 3).

The moving target gunnery results of Phase II are shown in Table 2. The difference between the means of the two conditions for

TABLE 2  
DATA OF PHASE II

Subject	Condition		Gunnery Scores	
	Fired	First	Without AR	With AR
1	W/O	AR	20	12
2	W	AR	32	24
3	W/O	AR	32	24
4	W	AR	42	12
5	W/O	AR	18	30
6	W	AR	32	10
7	W/O	AR	10	22
8	W	AR	14	18
9	W	AR	12	36
10	W/O	AR	22	28
TOTAL			234	216
$\bar{X}$			23.4	21.6
$\sigma$			10.04	8.14

this phase, as hypothesized, was not statistically significant. It can be seen that gunner variability (as evidenced by the standard deviation for the mean of the scores) was much larger than the difference between the means for the two experimental conditions. Clearly, then, the time delay induced by the AR device did not adversely affect moving target gunnery by expert gunners. There is no reason to believe novice gunners' results would be any more affected than were those of the experts used in this experiment.

The gunners who participated in the experiment, with one exception, said they did not notice the reflex eliciting signal. The exception, subject 10, said that it bothered him, but he fired better with the system operating than without it. A comparison of the AR sound output levels used in Phase I and Phase II shows that the output levels used in Phase II (104 and 122 db) were at least as loud as those found in Phase I (94, 102, and 122 db). Therefore, distraction effects, if any, as a function of presentation of a loud sound, should have been at least as large in Phase II as in Phase I.

#### IV. DISCUSSION

The significant protection shown to accompany use of the AR Ear Defender System without adverse effect upon tank gunnery suggests that the inclusion of the system in combat vehicles would provide a considerable measure of hearing protection without interfering with tactical employment. The desirability of the system is enhanced since it does not interfere with communication and is in use only when it is actually needed, i. e., only when the firing switch is closed. Furthermore, no supervision or fitting of the wearers is necessary as protection ensues upon the activation of the operational device in the tank regardless of the efforts and feelings of the crew members. Additional positive aspects of the system are that it occupies little space (about 2" x 5" x 8"), necessitates no change in existing equipment, and is demonstrably compatible with the communications in and planned for combat vehicles.

It is believed that the AR Ear Defender System, in conjunction with the CVC helmet now type classified for combat vehicle crewmen, would significantly reduce noise induced hearing loss and therefore hearing loss compensation costs. An additional benefit would accrue in the reduction of the need to replace experienced crew members because of loss of hearing, and in the associated reduction in training costs. It is possible that use of this system could also significantly reduce

communication errors by reducing noise induced temporary and permanent hearing losses.

## V. RECOMMENDATION

In the interest of reducing the direct and indirect costs of noise induced hearing loss, it is recommended that the Acoustic Reflex Ear Defender System be adopted for use in combat vehicles.

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STEROID-PROTEIN INTERACTIONS. VIII. STRUCTURE OF  
 $\Delta^4$ -3-KETOSTEROIDS IN RELATION TO SPECTRO-  
PHOTOMETRIC INTERACTION WITH HUMAN SERUM  
ALBUMIN - U. Westphal and B. D. Ashley  
Report No. 523. 20 Dec 61. 15 pp & ii - 6 tables  
Project No. 6X64-12-001. Unclassified Report

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1. Biochemistry  
2. Steroid  
Hormones  
3. Proteins  
4. UV Absorption  
Spectrum

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